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December 1987

Gulf Menhaden, *Brevoortia patronus*, Purse Seine Fishery, 1974-85, with a Brief Discussion of Age and Size Composition of the Landings

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Gulf Menhaden, *Brevoortia patronus*, Purse Seine Fishery, 1974-85, with a Brief Discussion of Age and Size Composition of the Landings

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ABSTRACT

Routine biostatistical port sampling data and landings records collected from the gulf menhaden purse seine fishery between 1974 and 1985 are updated. During most of the period, a total of 11 menhaden reduction plants operated in Mississippi and Louisiana, and the number of vessels in the purse seine fleet varied from 71 to 82. Total annual landings ranged from 447,100 metric tons in 1977 to the record landings for the fishery of 982,800 metric tons in 1984. Age-1 and -2 gulf menhaden annually comprised almost 96% of the landings. Estimated total numbers of menhaden landed varied from 4,510.5 million in 1975 to 11,154.9 million in 1985. Annual mean lengths and weights of sampled fish-at-age showed little variation. Nominal or observed fishing effort gradually increased through the 1970s and 1980s, reaching 655,800 vessel-ton-weeks in 1983.

Introduction

The purse seine fishery for gulf menhaden, *Brevoortia patronus*, in the Gulf of Mexico dates from the late 1800s, although annual landings prior to World War II were sporatic and generally less than 10,000 metric tons (mt) (Nicholson 1978). After World War II the demand for fish meal increased due to growth of the poultry industry and the fishery underwent rapid expansion and modernization. By 1969 over 500,000 mt of fish were landed (Nicholson 1978). The fishery continues to dominate U.S. fisheries production, annually averaging 27% by volume of the total U.S. fisheries landings between 1974 and 1985 (Table 1). Chief products marketed by the gulf menhaden industry are fish meal and fish solubles, used as supplements in poultry feed, and fish oil, primarily used as a refined edible oil in Europe and Canada.

Gulf menhaden are exploited in near-coastal waters from western Florida to eastern Texas, although reduction plants are presently located only in Mississippi and Louisiana (Fig. 1). Two congeneric species of menhaden also occur in the Gulf of Mexico, the yellowfin menhaden, *B. smithi*, and the finescale menhaden, *B. gunteri*, although they comprise less than 1% of the menhaden landed (Nicholson 1978).

In 1964 the Beaufort Laboratory of the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries until 1970) began compiling biostatistical and catch and effort data for the gulf menhaden fishery. This work was fostered by concern that gulf menhaden might succumb to overfishing and catches decline, as had occurred in the Atlantic menhaden fishery during the 1960s. By the early 1970s biological data suggested that the gulf menhaden resource was almost fully exploited and that the time had arrived for state, federal, and industry representatives to outline possible management strategies (Chapoton 1972). In 1977 the five Gulf states voted in favor of a cooperative management system for gulf menhaden under the auspices of the Gulf States Marine Fisheries Commission (Christmas and Etzold 1977). Under this compact, management authority is vested in the states, and some regulations such as vessel licensing, restricted or closed fishing areas, and allowable bycatch are regulated on a state-specific basis. Through this cooperative agreement, the 26-week fishing season, from the third Monday in April through the Friday following the second Tuesday in October, became uniform throughout the Gulf

Table 1
Percent contribution of gulf menhaden landings to total U.S. fisheries landings, 1974-85.

Year	Total U.S. fisheries landings (10^9 lbs)	Gulf menhaden landings (10^9 lbs)	Percent contribution of gulf menhaden landings to U.S. total landings
1974	4.9	1.3	27
1975	4.8	1.2	25
1976	5.4	1.2	22
1977	5.2	1.0	19
1978	6.1	1.8	30
1979	6.3	1.7	27
1980	6.5	1.6	25
1981	6.0	1.2	20
1982	6.4	1.9	30
1983	6.4	2.0	31
1984	6.4	2.2	34
1985	6.3	2.0	32
12-yr mean	5.9	1.6	27

Data sources: U.S. Department of Commerce, 1975-86.

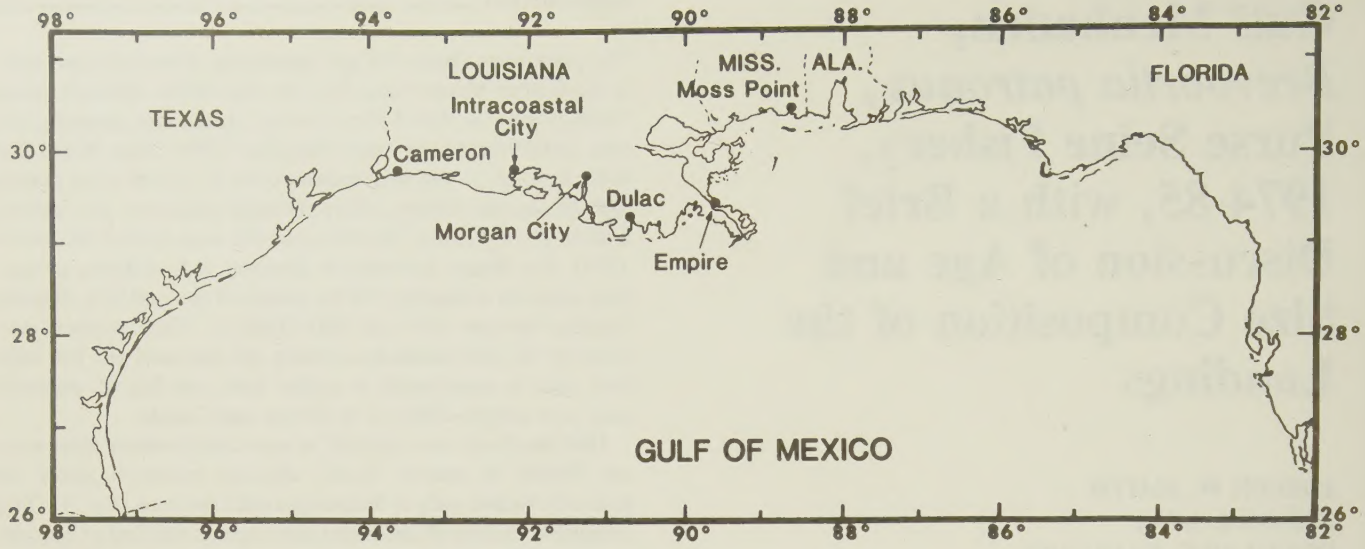

Figure 1
Location of reduction plants for the gulf menhaden purse seine fishery, 1974-85.

states. No state limits catch or fishing effort of vessels. This regional management plan was revised in 1983 (Christmas et al. 1983).

Nicholson (1978) summarized information on the evolution of the modern gulf menhaden fishery up to 1973, described sampling and estimation procedures for numbers of fish-at-age, discussed size and age composition of the landings, and described trends in catch-per-unit-effort (CPUE) from 1964 to 1973. The purposes of this paper are to update routine biostatistical and catch and fishing effort data collected from the gulf menhaden purse seine fishery during 1974-85, to document changes in the fishery, and to discuss age and size composition of the landings.

Changes in the Fishery

Number of reduction plants

During the early 1950s menhaden reduction facilities operated in all Gulf states except Alabama (Nicholson 1978). Since then, the trend in the industry has been toward more efficient plants with greater reduction capacity. By 1972 menhaden processing on the Gulf coast was located entirely within coastal Louisiana and Mississippi, with landings in Louisiana predominating. Over the period 1975-83 the number of plants stabilized at 11 (Table 2), with five companies operating eight facilities in Louisiana and three in Mississippi.

In early 1984 one of the largest menhaden meal companies purchased its closest competitor, thus combining the two largest menhaden companies on the Gulf coast. After the purchase, the resulting company controlled seven of the 11 active Gulf plants and 53 of the 81 vessels in the Gulf fleet. Almost immediately, the company sought to consolidate its acquisitions and closed one of its plants at Moss Point, MS, in May 1984; several vessels were also deactivated, while others were reassigned to alternate plants. Consolidation continued into 1985, as the company closed two additional plants at Morgan City and Cameron, LA.

Also during 1985, economic factors forced the temporary closure of an additional independent plant at Empire, LA, the imposition of weekly quotas on the total catch of most vessels, and the termination of fishing operations for some vessels and plants in September or October, prior to the official season closure in mid-October. Thus, during 1985 only seven plants were active, representing three companies.

Number of vessels

As documented by Nicholson (1978), the gulf menhaden purse seine fleet increased rapidly through the 1950s, peaked in 1965 at 82 vessels, then fluctuated between 65 and 82 vessels from 1966 to 1974 (Table 2). Between 1975 and 1984 the number of vessels in the fleet varied between 78 and 82. Following the corporate consolidation in 1984, the number of active vessels declined to 73 in 1985.

The industry's trend toward larger, faster vessels with greater carrying capacities (Nicholson 1978) continued into the 1980s. Vessels with a carrying capacity of over 200 net tons first appeared in the fishery in 1955, and by 1973 they comprised 78% (51 of 65) of the fleet (Nicholson 1978; Table 2). By 1985, 92% (67 of 73) of the vessels in the fleet held more than 200 net tons, with 57% (38 of 67) of these vessels carrying over 300 net tons and four vessels carrying over 400 net tons.

Total landings

Offloadings records for individual vessels were usually acquired monthly during the fishing season from confidential company sources. Landings in metric tons are reported by state (Table 3), except for 1974 and 1985 when only two companies operated in Mississippi; for these years landings from Mississippi and Louisiana were combined to protect confidential data.

Larger, faster, more efficient vessels and improved fishing technologies were primarily responsible for improved landings of gulf menhaden through the 1960s and early 1970s (Nicholson 1978). Greatest landings of the period were 728,200 mt in 1971 which surpassed record landings of 712,100 mt for the Atlantic menhaden fishery in 1956. Between 1974 and 1981 gulf menhaden landings

Table 2
Number of active plants and vessels by size in the gulf menhaden purse seine fishery, 1945-85.

Year	Number of active plants	Number of vessels[1] ≤75 net tons	76-200 net tons	>200 net tons	Total
1945	2	10	0	0	10
1946	3	13	1	0	14
1947	4	21	9	0	30
1948	5	27	12	0	39
1949	7	36	17	0	53
1950	10	42	23	0	65
1951	10	42	26	0	68
1952	10	41	23	0	64
1953	10	46	24	0	70
1954	9	40	32	0	72
1955	9	39	31	2	72
1956	10	38	39	4	81
1957	10	32	35	6	73
1958	10	20	48	9	77
1959	11	18	44	11	73
1960	10	12	52	11	75
1961	10	6	52	11	69
1962	12	6	54	14	74
1963	11	5	53	15	73
1964	11	5	53	18	76
1965	13	4	48	30	82
1966	13	1	42	37	80
1967	13	1	32	43	76
1968	14	2	26	41	69
1969	13	2	27	43	72
1970	13	2	26	45	73
1971	13	1	29	52	82
1972	11	0	22	53	75
1973[2]	10	0	14	51	65
1974	10	0	14	57	71
1975	11	0	14	64	78
1976	11	0	14	68	82
1977	11	0	11	69	80
1978	11	0	11	69	80
1979	11	0	8	70	78
1980	11	0	7	72	79
1981	11	0	6	74	80
1982[3]	11	0	7	75	82
1983	11	0	7	74	81
1984	11	0	7	74	81
1985	7	0	6	67	73

[1]Number of vessels landing menhaden at least one day in each of nine or more weeks, 1945-73. Number of vessels landing menhaden at least one day, 1974-85.
[2]1945-73 data from Nicholson (1978).
[3]1974-82 data from Chapoton in Christmas et al. (1983).

Table 3
Gulf menhaden purse seine landings (10^3 metric tons) by state, 1945-85.

Year	Florida	Mississippi	Louisiana	Texas	Total
1945	3.2	26.0	0.0	0.0	29.2
1946	(1)	(1)	8.9	0.0	(1)
1947	(1)	10.1	24.0	0.0	(1)
1948	15.4	34.8	40.0	12.7	102.9
1949	11.2	30.1	75.2	19.0	135.5
1950	0.6	31.1	94.3	21.2	147.2
1951	1.5	43.4	96.7	13.2	154.8
1952	4.8	70.7	129.2	24.0	228.7
1953	2.0	22.1	142.1	30.3	196.5
1954	0.0	36.0	121.8	23.4	181.2
1955	0.9	56.0	135.1	23.0	215.0
1956	0.0	70.3	144.6	29.9	244.8
1957	0.0	59.3	74.5	26.1	159.9
1958	4.6	56.1	109.5	31.3	201.5
1959	8.2	79.7	191.5	55.9	335.3
1960	2.8	99.1	213.2	65.6	380.7
1961	1.9	136.7	260.2	60.7	459.5
1962	0.0	119.5	314.1	47.1	480.7
1963	0.0	113.6	288.4	35.8	437.8
1964	0.0	107.8	271.4	30.2	409.4
1965	0.0	126.4	308.6	28.1	463.1
1966	3.1	86.4	252.0	17.6	359.1
1967	0.0	75.5	231.4	10.4	317.3
1968	0.3	67.8	282.2	23.2	373.5
1969	0.0	102.2	388.3	33.2	523.7
1970	0.0	93.4	435.2	19.5	548.1
1971	0.0	138.8	560.9	28.5	728.2
1972	0.0	80.8	420.9	0.0	501.7
1973[2]	0.0	80.4	405.7	0.0	486.1
1974	0.0	587.4 [3]		0.0	587.4
1975	0.0	96.2	446.4	0.0	542.6
1976	0.0	81.7	479.5	0.0	561.2
1977	0.0	103.9	343.2	0.0	447.1
1978	0.0	135.6	684.4	0.0	820.0
1979	0.0	144.4	633.5	0.0	777.9
1980	0.0	118.9	582.4	0.0	701.3
1981	0.0	87.8	464.8	0.0	552.6
1982	0.0	142.9	711.0	0.0	853.9
1983	0.0	165.5	758.0	0.0	923.5
1984	0.0	186.2	796.6	0.0	982.8
1985	0.0	881.1 [3]		0.0	881.1

[1]Records not available.
[2]1945-73 data from Nicholson (1978).
[3]Landings from two states combined to protect confidential data.

fluctuated between 447,100 and 820,000 mt (Table 3). Beginning in 1982, record landings were established for three consecutive years, culminating with 982,800 mt in 1984. Had it not been for poor economic conditions, landings in 1985 might have rivaled the record landings of the previous year. During April and May 1985, landings outpaced respective monthly landings for the previous two years. By June 1985, however, most companies implemented restrictive vessel catch quotas due to prevailing economic conditions, and landings declined significantly.

Since the early 1950s, landings in Louisiana have dominated total gulf menhaden landings (Table 3), and between 1964 to 1973 annual landings in Louisiana averaged 74% of the Gulf's menhaden production. Between 1975 and 1984[1] annual landings in Louisiana averaged 82% of the total gulf menhaden landings.

Effort and CPUE

The unit of nominal fishing effort used for the gulf menhaden purse seine fishery is the vessel-ton-week. Seasonal nominal fishing effort by vessel is the product of the vessel's net registered tonnage multiplied by the number of weeks that the vessel fished (landed fish at least one day in the week) (Christmas et al. 1983). Since, on average, large vessels in the gulf menhaden fleet catch more fish than small vessels, the vessel-ton-week explains some of the differences in efficiency within the gulf menhaden fleet, more so than the vessel-week unit used for the Atlantic menhaden fleet (Schaaf et al. 1975). Catch-per-unit effort is recorded in metric tons per vessel-ton-week.

[1]Gulf menhaden landings by individual states for 1974 and 1985 are combined to protect landings confidentiality, as only two plants operated in Mississippi during those years.

Nominal effort in the gulf menhaden purse seine fishery gradually increased through the 1970s and 1980s to about 650,000 vessel-ton-weeks (Table 4). CPUE values show peaks in the range of 1.45 to 1.60 mt/vessel-ton-week during 1964, 1971, 1979, and 1985, with modest declines during intervening years (Table 4). In the short term, i.e., adjacent years, CPUE values may tend to reflect gulf menhaden abundance. However, factors such as increased vessel efficiencies, increased plant efficiencies and capacities, and company-imposed quotas (1985 fishing season) do not enter into CPUE computations; thus in the long term, CPUE values are not an accurate indicator of gulf menhaden abundance.

Table 4

Total landings (10^3 metric tons), nominal fishing effort (in thousands of vessel-ton-weeks), and CPUEs for the gulf menhaden purse seine fishery, 1964-85.

Year	Total landings (10^3 mt)	Nominal fishing effort (10^3 vessel-ton-weeks)	CPUE (mt/ vessel-ton-week)
1964	409.4	272.9	1.50
1965	463.1	335.6	1.38
1966	359.1	381.3	0.94
1967	317.3	404.7	0.78
1968	373.5	382.3	0.98
1969	523.7	411.0	1.27
1970	548.1	400.0	1.37
1971	728.2	472.9	1.54
1972	501.7	447.5	1.12
1973	486.1	426.2	1.14
1974	587.4	485.5	1.21
1975	542.6	538.0	1.01
1976	561.2	575.8	0.97
1977	447.1	532.7	0.84
1978	820.0	574.3	1.43
1979	777.9	533.9	1.46
1980	701.3	627.6	1.12
1981	552.6	623.0	0.89
1982	853.9	653.8	1.31
1983	923.5	655.8	1.41
1984	982.8	645.9	1.52
1985	881.1	560.6	1.57

Age and Size Composition of Landings

As outlined in Nicholson (1978), landings of gulf menhaden were sampled by procedures and techniques originally developed for sampling Atlantic menhaden (June and Reintjes 1960). Vessels were randomly sampled and fish were collected in a bucket from the top of the hold, which came from the vessel's final set. Beginning in 1974, 10 fish (compared with 20 fish prior to 1974) were randomly chosen from the bucket and each measured for fork length (mm), weighed (g), and scales removed for ageing (specimens were not sexed after 1973). Between 1974 and 1985 the number of 10-fish samples acquired per plant through a fishing season ranged from 17 to 336 (Table 5). During the same period, the total number of 10-fish samples collected at all plants over an entire fishing season ranged from 955 to 1,598.

Estimates of the number of fish landed by age were made following procedures described in Nicholson (1978). Fish age-4 and older were pooled because the method of ageing fish older than age-4 is assumed to be unreliable (Nicholson and Schaaf 1978). Historic port sampling data for size and age composition were reexamined for errors using recently developed computer programs for editing data. Corrections were made to the data set where appropriate. Our estimated numbers of fish-at-age for 1964-79 may differ with earlier reports (Nicholson 1978; Christmas et al. 1983; Nelson and Ahrenholz 1986) because of corrections in the biostatistical database. Modifications in estimated numbers of fish are slight and do not significantly differ from previously published values. Because gulf menhaden are believed to comprise a single genetic stock (Christmas et al. 1983), we present estimated numbers of fish-at-age caught coastwide (Appendix Tables 1 and 2), rather than dividing the estimates into eastern, central, and western fishing grounds as did Nicholson (1978).

Gulf menhaden are aged by counting annual rings on scales. About 12,200 specimens were examined annually between 1974 and 1985. Estimated numbers of gulf menhaden by age landed in the purse seine fishery for 1964-85 are shown in Table 6. Noteworthy is the paucity of age-0 fish in the landings after 1975. An explanation for this is tied to the work of Nicholson and Schaaf (1978), who found that a portion of the fish examined during each sampling year failed to have deposited an annual ring at the end of the first or second year of growth. Although somewhat subjective, they assigned ages to these fish based on fish length at capture,

Table 5

Number of 10-fish samples gathered from gulf menhaden landings by plant location, 1974-85.

Plant location	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Moss Pt., MS	(1)	49	102	109	149	106	54	99	127	107	0(2)	(1)
(3 plants)	152	71	195	171	164	117	80	95	158	115	224	223
	169	70	124	121	91	71	40	68	93	73	194	254
Empire, LA	131	117	125	188	161	143	122	129	149	201	181	231
(2 plants)	122	132	118	221	131	90	117	117	107	135	96	(1)
Dulac, LA	80	110	84	72	93	173	106	76	88	133	209	198
Morgan City, LA	24	70	61	63	61	69	81	77	64	109	104	(1)
Intracoastal City, LA	74	114	132	156	161	148	134	153	214	211	336	217
Cameron, LA	93	81	145	144	76	83	108	56	20	169	79	(1)
(3 plants)	123	88	153	132	101	84	104	105	31	127	98	50
	68	53	116	117	111	79	66	66	17	107	77	151
Total	1,036	955	1,355	1,494	1,299	1,163	1,012	1,041	1,068	1,487	1,598	1,324

[1]Plant did not operate.
[2]Plant operated only one month.

Table 6

Estimated numbers (10^6) of gulf menhaden by age landed annually, 1964-85, by purse seine vessels.

Year	Age (yr) 0	1	2	3	4+	Total
1964	2.76	3,329.28	1,495.15	118.07	4.35	4,949.61
1965	43.43	5,031.39	1,076.63	80.27	0.70	6,232.41
1966	30.45	3,314.42	865.16	33.76	0.26	4,244.05
1967	22.44	4,267.65	337.66	13.00	0.00	4,640.74
1968	65.06	3,475.23	1,001.30	37.45	0.50	4,579.55
1969	20.80	6,075.00	1,286.34	31.66	0.00	7,413.81
1970	50.19	3,279.85	2,279.98	36.08	0.00	5,646.10
1971	21.59	5,761.13	1,955.45	181.84	4.12	7,924.12
1972	19.11	3,047.74	1,733.53	88.54	4.03	4,892.95
1973	49.90	3,033.00	1,106.98	99.62	1.27	4,290.77
1974	1.41	3,846.75	1,471.65	59.08	0.00	5,378.89
1975	108.77	2,440.51	1,499.21	461.83	0.19	4,510.51
19761	0.00	4,591.39	1,373.94	203.92	0.00	6,169.25
1977	0.00	4,659.95	1,331.72	110.37	5.63	6,107.66
1978	0.00	6,787.44	2,742.01	52.67	5.24	9,587.37
1979	0.00	4,701.22	2,877.16	337.20	6.81	7,922.39
1980	65.86	3,409.41	3,261.11	436.15	47.86	7,220.39
1981	0.00	5,750.53	1,424.94	329.40	34.22	7,539.08
1982	0.00	5,146.74	3,301.96	503.54	62.26	9,014.50
1983	0.00	4,685.73	3,809.23	382.61	25.10	8,902.67
1984	0.00	7,749.55	2,881.49	438.36	49.75	11,119.14
1985	0.00	8,127.64	2,723.64	283.04	20.58	11,154.90

[1]Since 1976, most specimens ~135 mm FL with no scale rings have been designated age-1 fish instead of age-0 (see text).

time of capture, and ring location on scales. Additionally, they found that a small number of gulf menhaden, ~115-135 mm fork length, which appear in the landings during August to October show no rings on their scales. They thought these fish were age-0, but they were not certain "because many of the fish in this size range of age 1 fish also have no scale rings". During 1964-75 some of these fish were categorized as age-0. Since 1976 we have generally designated these fish as age-1. One reason for this change was the work of Ahrenholz (Beaufort Lab., Southeast Fish. Cent., Beaufort, NC 28516, unpubl. data) who found that young-of-the-year gulf menhaden (age-0) tagged during September and October had not been taken by the fishery during the year of tagging, rather they were readily recaptured during their second and third summers as age-1 and -2 fish, respectively (see Ahrenholz 1981 for a description of juvenile tagging methodologies and project results). Therefore, we believe very few age-0 gulf menhaden are harvested by the fishery. Since 1976 we have generally designated these problematic fish as age-1, and annually the specimens in question averaged less than 1% of the fish sampled.

Between 1974 and 1985 annual estimates of numbers of gulf menhaden landed ranged from 4,510.5 million in 1975 to 11,154.0 million in 1985 (Table 6). Although record landings of 982,800 mt for the gulf menhaden fishery occurred in 1984, we estimate that slightly more fish were taken in 1985 when 881,100 mt were landed. Combined age-1 and -2 gulf menhaden annually averaged almost 96% of landings for the period 1974-85; age-3 fish averaged 4%, and combined ages-0 and -4+ averaged less than 1%. Age-1 fish annually contributed between 47 and 76% of the total numbers of fish landed, while age-2 fish contributed 19 to 45%.

Although nominal fishing effort has generally increased (Table 4), the exceptionally large year-classes recruited to the fishery since the late 1970's have resulted in a decline in effective fishing effort (proportional to population fishing mortality rate, F) (Vaughan 1987). Greater numbers of fish age-4 and older (Table 6) indicate greater survival to these older ages.

Our observations on annual mean length and weight of gulf menhaden in purse seine landings are commensurate with those of Nicholson (1978) who reported that little variation occurred annually in the length range or mean length. Between 1974 and 1985 annual mean lengths ranged from 147 to 165 mm for age-1 fish, 177 to 199 mm for age-2 fish, and 201 to 220 mm for age-3 fish (Table 7). Likewise, annual mean weights showed little variation: age-1 fish ranged from 62 to 98 g, age-2 fish from 113 to 164 g, and age-3 fish from 165 to 216 g (Table 8).

Conclusions

Through 1975-83 the gulf menhaden purse seine fishery remained relatively stable with 11 reduction plants in operation and concentrated in two Gulf states: eight plants in Louisiana and three in Mississippi. Corporate acquisition in 1984 resulted in the closure of three plants by 1985, while poor economic conditions in 1985 forced the temporary closure of an additional plant. By 1985 the number of active plants had been reduced to seven.

Fleet size remained fairly stable between 1975 and 1984, varying from 78 to 82 vessels, but then declining to 73 vessels in 1985. Trends toward larger and faster vessels continued into the 1980s, and by 1985 over 50% of the fleet (38 of 73) had net holding capacities in excess of 300 net tons. During 1974-81 total landings fluctuated between 447,100 and 820,000 mt. Beginning in 1982 and for four consecutive years, total landings exceeded 800,000 mt and culminated in 1984 with record landings for the fishery of 982,800 mt. Total nominal effort in the fishery exceeded 600,000 vessel-ton-weeks in 1980, and peaked at 655,800 vessel-ton-weeks in 1983.

Record landings of recent years are related to increased stock size due to exceptionally large year-classes entering the fishery in the late 1970s and early 1980s (Vaughan 1987). Total numbers of fish landed increased from an estimated 5.38 billion fish in 1974 to 11.15 billion fish in 1985. Through the same period, combined age-1 and -2 fish annually averaged about 96% of the estimated numbers of fish landed, while annual mean lengths and weights for age-1 to -3 gulf menhaden showed little variation.

Table 7

Mean fork length (mm) of gulf menhaden in combined samples of landings from all ports by year, quarter, and age, 1964-85.

	Quarter 2 Age (yr)					Quarter 3 Age (yr)					Quarter 4 Age (yr)					Overall Age (yr)					Total
Year	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	aged
1964	—	148	180	199	214	120	158	188	205	215	129	159	180	—	—	122	154	184	201	214	12,244
1965	—	140	178	198	206	117	154	187	209	240	118	150	189	216	—	117	147	181	204	231	15,165
1966	—	149	179	201	—	116	160	186	205	227	—	167	—	—	—	116	155	182	203	227	12,418
1967	—	142	178	199	—	102	158	185	207	—	—	167	192	—	—	102	151	181	202	—	14,052
1968	—	146	177	205	—	132	163	187	224	235	124	171	193	227	—	131	157	182	214	235	15,312
1969	—	140	183	206	—	123	154	188	210	—	—	157	193	232	—	123	149	186	207	—	14,739
1970	—	157	177	205	—	110	162	185	210	—	—	172	183	—	—	110	160	181	208	—	10,395
1971	—	152	186	204	230	119	159	190	204	218	—	161	188	—	—	119	157	188	204	222	7,654
1972	—	155	182	207	215	108	164	190	211	213	—	166	188	—	—	108	160	187	209	214	9,886
1973	—	159	185	212	230	120	168	190	214	239	130	167	190	222	—	121	165	188	214	236	8,953
1974	—	160	197	214	—	102	167	201	214	—	—	172	199	—	—	102	164	199	214	—	10,085
1975	—	159	191	216	258	120	164	198	221	—	135	171	205	223	—	124	163	196	219	258	9,527
1976	—	151	187	214	—	—	159	194	225	—	—	160	198	—	—	—	156	191	220	—	13,388
1977	—	146	181	208	235	—	148	184	211	238	—	152	185	212	—	—	147	182	210	237	14,897
1978	—	149	178	207	224	—	158	185	209	240	—	166	195	221	—	—	155	181	208	228	12,944
1979	—	153	186	202	210	—	159	190	206	217	—	162	188	—	—	—	157	187	204	213	11,121
1980	—	150	183	205	211	104	152	189	208	221	89	137	186	205	—	92	151	186	206	216	9,883
1981	—	144	174	199	212	—	149	178	204	216	—	139	166	—	—	—	147	177	201	214	10,273
1982	—	148	181	199	212	—	150	186	204	215	—	167	184	202	—	—	150	183	201	213	10,341
1983	—	146	182	203	212	—	156	187	204	221	—	163	192	206	221	—	154	185	204	216	14,523
1984	—	144	182	203	212	—	151	184	206	217	—	161	185	210	215	—	150	184	205	215	15,936
1985	—	146	179	205	213	—	151	182	208	214	—	150	182	208	216	—	149	181	207	214	13,225

Table 8

Mean weight (grams) of gulf menhaden in combined samples of the landings from all ports by year, quarter, and age, 1964-85.

	Quarter 2 Age (yr)					Quarter 3 Age (yr)					Quarter 4 Age (yr)					Overall Age (yr)				
Year	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
1964	—	64	127	182	220	34	77	138	183	206	41	76	115	—	—	36	72	131	182	219
1965	—	56	127	185	229	32	74	138	198	291	35	67	139	218	—	32	65	131	192	275
1966	—	71	125	177	—	31	84	137	180	229	—	95	—	—	—	31	78	130	178	229
1967	—	58	115	157	—	21	78	132	181	—	—	90	147	—	—	21	68	123	167	—
1968	—	62	114	176	—	51	88	139	241	289	35	105	153	249	—	51	79	125	207	289
1969	—	57	133	199	—	36	72	139	192	—	—	76	158	274	—	36	66	137	199	—
1970	—	77	115	179	—	30	86	133	194	—	—	105	128	—	—	30	83	125	189	—
1971	—	70	135	177	242	31	83	144	182	220	—	81	141	—	—	31	78	140	180	227
1972	—	75	124	171	169	25	87	144	191	194	—	92	127	—	—	25	82	136	182	189
1973	—	89	149	218	241	35	103	152	213	313	45	105	152	242	—	36	98	150	216	289
1974	—	83	161	203	—	26	93	167	199	—	—	102	164	—	—	26	89	164	200	—
1975	—	81	146	207	359	33	90	160	221	—	46	102	177	221	—	36	88	156	215	359
1976	—	70	130	191	—	—	80	140	202	—	—	91	157	—	—	—	76	135	197	—
1977	—	59	113	166	237	—	62	121	181	246	—	70	126	188	—	—	62	117	176	243
1978	—	66	115	185	231	—	79	129	189	282	—	95	159	236	—	—	74	123	188	244
1979	—	68	128	163	182	—	77	137	175	195	—	98	149	—	—	—	74	132	169	188
1980	—	70	126	178	197	19	66	142	186	224	29	53	136	180	—	27	66	134	183	213
1981	—	58	106	155	184	—	70	118	175	207	—	63	92	—	—	—	65	113	165	196
1982	—	64	124	163	192	—	69	134	175	201	—	105	141	174	—	—	67	130	168	196
1983	—	64	131	176	199	—	76	135	181	222	—	82	150	194	257	—	73	134	179	211
1984	—	61	130	179	214	—	70	130	182	210	—	90	137	192	210	—	69	130	181	212
1985	—	60	116	175	195	—	66	118	170	184	—	63	121	176	187	—	63	117	172	187

Acknowledgments

We wish to express our appreciation to menhaden plant owners and managers who provided records of vessel offloadings and also access for our port agents to sample gulf menhaden. We thank all past and present members of the Menhaden Program at the Beaufort Laboratory who contributed to the gulf menhaden database, especially William R. Nicholson who maintained menhaden biostatistical files until his retirement in 1984, Charles W. Krouse, Jr., for his computer programming talents, Dean W. Ahrenholz for his guidance and encouragement during preparation of the manuscript, and Beverly W. Harvey who typed numerous drafts of the manuscript. Sheryan P. Epperly, John V. Merriner, and James R. Waters made valuable comments on initial drafts.

We wish to dedicate this report to the memory of Robert (Bob) B. Chapoton who was a Branch Leader in the Menhaden Program at the Beaufort Laboratory until his untimely death in May 1985. During the early 1960s he devised and initiated the Program's port sampling survey for gulf menhaden. Through the years, Bob maintained gulf menhaden catch and effort data and served as scientific liaison to the menhaden industry and the Atlantic and Gulf States Marine Fisheries Commissions. In his final years, Bob's management philosophies on menhaden affected major decisions by menhaden companies on both the Atlantic and Gulf coasts, as well as reaching the highest levels of state and federal fisheries management agencies. Bob's contacts in the industry and fisheries management circles were also counted among his friends. His wit, steadfastness, and friendship will be missed by all who knew him.

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Appendix Table 1
Quarterly time increments used in stock assessment analyses for gulf menhaden.

Quarter	Beginning date	Ending date
1	1/1	<4/4
2	>4/3	<7/4
3	>7/3	<10/4
4	>10/3	12/31

Appendix Table 2

Estimated numbers of gulf menhaden (10^3) landed by purse seine vessels by year, quarter, and age, 1964-85.

	Age (yr)				
Quarter	0	1	2	3	4+
1964					
2	99	1,607,742	846,118	71,591	2,714
3	2,411	1,708,043	648,183	46,475	1,639
4	246	13,496	852	—	—
Totals	2,756	3,329,281	1,495,153	118,066	4,353
1965					
2	—	2,328,238	682,926	42,155	100
3	42,479	2,665,991	391,729	37,955	600
4	950	37,162	1,973	155	0
Totals	43,429	5,031,391	1,076,628	80,265	700
1966					
1	—	8,641	—	—	—
2	—	1,806,925	456,112	15,258	—
3	30,450	1,498,808	409,041	18,505	258
4	—	44	3	—	—
Totals	30,450	3,314,418	865,156	33,763	258
1967					
1	—	4,637	—	—	—
2	—	2,047,182	165,019	7,930	—
3	22,439	2,184,399	170,279	4,991	—
4	1	31,432	2,360	77	—
Totals	22,440	4,267,650	337,658	12,998	—
1968					
2	—	1,200,884	445,907	12,182	—
3	26,843	2,093,188	539,128	18,708	—
4	38,220	181,153	16,266	6,563	504
Totals	65,063	3,475,225	1,001,301	37,453	504
1969					
2	—	2,386,612	614,767	23,434	—
3	20,509	3,371,366	613,120	8,027	—
4	291	317,026	58,455	200	—
Totals	20,800	6,075,004	1,286,342	31,661	—
1970					
2	—	988,428	1,012,857	18,295	—
3	46,159	2,217,435	1,188,340	17,788	—
4	4,029	73,989	78,780	—	—
Totals	50,188	3,279,852	2,279,977	36,083	—
1971					
1	—	6,704	3,652	1,231	—
2	—	2,553,271	1,164,412	111,255	1,848
3	16,892	3,018,766	742,022	67,800	2,269
4	4,699	182,386	45,364	1,552	—
Totals	21,591	5,761,127	1,955,450	181,838	4,117
1972					
1	—	6,271	4,180	—	—
2	—	1,499,517	829,348	35,551	1,842
3	18,483	1,447,615	820,881	52,989	2,188
4	630	94,334	79,121	—	—
Totals	19,113	3,047,737	1,733,530	88,540	4,030
1973					
1	—	132	660	—	—
2	—	912,629	412,208	30,540	117
3	48,525	1,981,765	629,515	54,858	667
4	1,375	138,479	64,596	14,219	487
Totals	49,900	3,033,005	1,106,979	99,617	1,271
1974					
2	—	1,611,940	777,283	15,801	—
3	1,407	2,123,958	669,317	42,792	—
4	—	110,856	25,047	491	—
Totals	1,407	3,846,754	1,471,647	59,084	—

	Age (yr)				
Quarter	0	1	2	3	4+
1975					
2	—	723,570	511,340	250,484	191
3	65,513	1,595,516	866,811	178,197	—
4	43,257	121,425	121,059	33,146	—
Totals	108,770	2,440,511	1,499,210	461,827	191
1976					
2	—	1,508,212	660,107	79,593	—
3	—	2,945,593	702,432	120,912	—
4	—	137,587	11,400	3,413	—
Totals	—	4,591,392	1,373,939	203,918	—
1977					
2	—	1,828,995	743,564	54,359	2,238
3	—	2,684,240	577,863	55,375	3,254
4	—	146,713	10,292	635	136
Totals	—	4,659,948	1,331,719	110,369	5,628
1978					
2	—	3,173,917	1,434,341	35,649	3,841
3	—	3,155,722	1,174,856	17,026	1,400
4	—	457,804	132,816	—	—
Totals	—	6,787,443	2,742,013	52,675	5,241
1979					
2	—	1,429,172	1,499,976	155,386	3,821
3	—	2,776,241	1,265,298	160,466	2,991
4	—	495,805	111,890	21,346	—
Totals	—	4,701,218	2,877,164	337,198	6,812
1980					
2	—	428,521	1,667,589	212,927	23,278
3	6,661	2,557,327	1,384,854	210,227	23,469
4	59,197	423,563	208,668	12,998	1,113
Totals	65,858	3,409,411	3,261,111	436,152	47,860
1981					
2	—	2,213,414	681,532	193,544	18,347
3	—	3,329,908	677,802	125,742	14,679
4	—	207,205	65,604	10,116	1,189
Totals	—	5,750,527	1,424,938	329,402	34,215
1982					
2	—	2,102,238	1,413,133	330,382	41,620
3	—	2,711,714	1,791,318	160,681	19,962
4	—	332,791	97,508	12,473	679
Totals	—	5,146,743	3,301,959	503,536	62,261
1983					
2	—	1,382,746	1,233,830	169,821	7,225
3	—	2,764,068	2,296,239	187,818	15,604
4	—	538,912	279,160	24,975	2,267
Totals	—	4,685,726	3,809,229	382,614	25,096
1984					
2	—	2,544,555	1,248,185	169,766	20,344
3	—	4,888,625	1,439,535	221,924	24,385
4	—	316,373	193,767	46,669	5,017
Totals	—	7,749,553	2,881,487	438,359	49,746
1985					
2	—	3,195,215	1,722,688	201,030	4,713
3	—	4,455,768	922,899	78,585	15,574
4	—	476,657	78,057	3,421	291
Totals	—	8,127,640	2,723,644	283,036	20,578

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